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ABSTRACT

Determining the feasibility of modifying existing buildings to take advantage of solar energy requires a formal technical study. This workbook is designed to help the reader perform a preliminary analysis to decide whether investing in such a formal study would be beneficial. The book guides the user through an exploration of the general characteristics of solar energy as they relate to the user's buildings, then helps the user consider the application of active and passive solar systems to the situation identified. A final section discusses the implications of the results of the user's survey. Aspects of solar energy use covered include building life, periods of occupancy, shading conditions, types of collectors and storage methods available, and relative costs and benefits involved in different applications. (PGD)

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New York State Energy Office

Solar Workbook

February 1980

A step by step procedure for assessing solar opportunities in existing buildings in New York State

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EA 013 579

This workbook was developed by the New York State Energy Office, with the assistance of the joint venture of the firms of Perkins & Will and The Ehrenkrantz Group, P.C., and with the assistance of Kallen & Lemelson.

Funding was provided under a grant from The Northeast Solar Energy Center, Boston, Massachusetts.

Messages

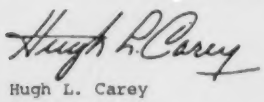
Governor Carey

Foremost as a threat to our economic health is our dependence on foreign oil.

To state the problem in its simplest form: we burn too much oil--more than 19 billion gallons a year, two-thirds of which is foreign oil...

We must accomplish two major energy policy objectives: consume less energy and substitute other energy sources for oil.

As we focus on greater use of all indigenous and renewable resources within the State, this Solar Workbook will help you make an initial judgment about using solar energy in your building. By considering solar energy as an alternative resource for our public and private buildings, we will be moving in a direction which has the potential to reduce expenditure of public and private energy dollars, and can lessen our dependence on imported petroleum products. More than ever before, energy self-sufficiency is a goal we must all actively pursue.*



Hugh L. Carey
Governor

February 1980
*Excerpted in part from 1980 Annual Message
to the New York State Legislature

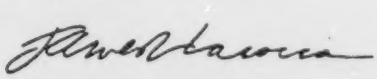
Commissioner Larocca

The State Energy Office is committed to promoting renewable energy resources. By increased use of renewable resources, we can reduce our dependence on imported fuels and create new job opportunities.

Since its creation in 1976, the New York State Energy Office has been actively involved in the planning and implementation of solar energy programs to remove barriers to solar energy use.

The State Energy Office has developed this Workbook for the purpose of eliminating a significant initial barrier to solar energy use--the problem of "What do I do first?". This Workbook will enable individuals involved in the operation of buildings to make a preliminary feasibility determination about solar energy before hiring a consultant or investing in an in-depth technical analysis. Among the many public and private building types that the Workbook can effectively screen are schools, hospitals, colleges and offices; health care, correctional, fire, police and other public service facilities; and multi-family housing and community residence facilities. The Workbook also complements the Federal Schools, Hospitals, Local Government and Public Care Institutions Buildings Grant Program solar assessment. Use of the Workbook does not require a technical background or prior familiarity with solar energy.

If you would like additional information on this or any other program of the State Energy Office, please call our toll-free New York State Energy Hotline at (800) 342-3722.



James L. Larocca
Commissioner

February 1980

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Introduction

Solar Energy

Each day our buildings require energy to provide for heating, cooling, electric power and light. Usually, this energy is supplied through the use of costly and depletable fossil fuels. Meanwhile, the sun shines above - a renewable resource waiting to be better utilized.

Why not take a closer look at how the sun's energy might work for you?

This Workbook will help you assess the possibility of modifying your existing building to take deliberate advantage of various solar energy applications. Many public and private building types can be evaluated with this Workbook including schools, offices, hospitals, colleges, correctional, fire, police and other public service facilities, as well as multi-family houses and community residences.

By using this Workbook, you will be able to determine whether a technical solar feasibility study is an investment worth considering for your building(s). In keeping with that objective, only those buildings which are clearly impractical for solar applications will be screened out by this Workbook. Other buildings may be worthy candidates for further technical consideration beyond the scope of this Workbook. In these cases, the Workbook will suggest that you consider hiring a consultant to perform an in-depth analysis for your building(s).

Let's begin.

To Use This Workbook

No prior knowledge of solar energy is needed - nor is a technical background required, however, you will need:

- to know your utility costs;
- the use of a small calculator, if available;
- a set of building plans, if available; and,
- approximately two hours of your time on a sunny day.

Workbook Organization

This Workbook is organized by dark gray divider pages into four related sections, which should be followed in order.

The first section, GENERAL CONSIDERATIONS, explores general issues and aspects of your building(s) which will often reveal if solar energy use is appropriate or possible. Such items as building life, periods of occupancy and preliminary shading conditions are examined.

The second section is ACTIVE SOLAR OPPORTUNITIES. You are probably familiar with active systems, which typically include rooftop-mounted collectors to heat hot water or air. This section allows you to consider the practicality and calculate the economics of a solar system to provide for a portion of your building's hot water needs. Also included are brief evaluations of other active solar applications.

The third section examines PASSIVE SOLAR OPPORTUNITIES. Passive systems are those in which solar energy flows naturally with minimal need for energy-consuming equipment. This section includes a procedure to help you consider the practicality and calculate the economics of using available daylight to reduce your energy consumption for lighting. Other possible passive options which may apply to your building(s) are also described.

The fourth section is DISCUSSION OF RESULTS. In addition to reviewing your results, the assumptions made to simplify the Workbook are explained. Also, sources for more information and ideas about how to wisely consider investment in solar energy systems are included.

Format

This Workbook is easy to use and follows this pattern:

- Right-hand pages which are printed in black always contain the basic text and provides space for your calculations and answers.
- Left-hand pages are printed in gray and are used to present support information, such as tables, diagrams, sketches, "Sun Spots" and examples, that help to explain the material presented on the right-hand pages.

New York State
Energy Hot Line

(800) 342-3722
TOLL-FREE

Instructions for Use

As you proceed through the Workbook, fill-in or circle your answers to each question, skipping only those questions which do not pertain to your building(s). Follow the Workbook in order, since that is the only way to accurately assess the solar potential of your building.

Should questions arise, call toll-free, the New York State Energy Hot Line at (800) 342-3722.

Your Contribution

The Energy Office is very interested in your findings to help in the formulation of future programs and New York State policies. Therefore, please mail a completed Answer Sheet, found at the end of the Workbook, back to the Energy Office as soon as possible. If you have surveyed more than one building, please make copies and return an Answer Sheet for each building surveyed. We thank you in advance for your assistance.

Results

Completion of this Workbook will result in your having a better knowledge of the factors which influence the use of solar energy and the likely costs and benefits of solar options for your building(s). This information will help you to decide if an in-depth technical analysis, beyond the scope of this Workbook, is in order.

General Considerations

Introduction

Not every existing building is a good candidate for solar energy use. In this section, factors which may work for or against the various active and passive solar opportunities will be explored as follows:

- Type of Building(s)
- Building Life
- Planned Alterations
- Historic Buildings
- Preliminary Shading
- Structural Capacity
- Periods of Occupancy

Type of Building(s)

Perhaps, instead of an individual building, you have a group of buildings, such as a college campus or health-related facility.

Is your facility a group of buildings, rather than a single structure?.....Yes or No

(1)

For facilities with more than one building, the following conditions are usually true.....

- Consumption of hot water and other energy needs are large.
- There are many potential areas for collectors on rooftops or ground level areas.
- Groups of buildings frequently present solar opportunities not offered by an individual building.

If the results of using this Workbook to evaluate your group of buildings are encouraging, it is likely that a detailed technical assessment beyond the scope of this Workbook may reveal attractive options specifically suitable to your facility.

Building Life

The expected life of a building must be considered since investment in an active solar system generally requires several years to repay its cost. For some buildings the expected life may not be known or estimated. In such instances, an educated guess can be helpful. Keep in mind that most well-maintained buildings remain structurally useful for 75 to 100 years or longer.

Has the expected life of your building been estimated or determined?.....Yes or No _____ (2)

If the answer is yes, for how many more years is the building expected to be useful?..... _____ Years (3)

Depending upon your answer, if your building has an expected life of:

- Less than 2 years, you should stop this Workbook investigation now, since solar investments for your facility would be unsound. Remember, however, to fully explore solar opportunities in any future planning for a new building.
- Between 2 and 5 years, you probably should skip the section on ACTIVE SOLAR OPPORTUNITIES, since they almost always take longer than this period of time to return their investment. Be sure, however, to complete the section on PASSIVE SOLAR OPPORTUNITIES, since the daylight option investigated may prove to be cost-effective for your building.
- More than 5 years, you should complete the entire Workbook. Consider investing in solar options only if building life will be longer than the time required to repay its cost and if the payback period is acceptable to you. Methods to evaluate solar options using simple payback and rate of return on investment are presented later in the Workbook.

Planned Alterations

Buildings are frequently altered or expanded, and such factors must be fully considered before making any final decision to implement a solar option.

Are there any plans to expand your building by adding floors?.....Yes or No

(4)

Do you expect to alter your interior spaces in the next 10 years?.....Yes or No

(5)

If you have indicated YES to either question, you must exercise particular caution before making a solar investment. For example, if more floors are being planned above the roof area where you would mount collectors, it would be best to either wait until the expansion to install any rooftop solar system, or to consider ground-mounting of the collectors if space is available now. Similarly, if interior spaces are likely to be altered, it may be unwise to modify existing lighting fixtures to capture passive daylighting until after the alterations are made.

Historic Buildings

Historic buildings should normally be changed or added to only in ways which do not detract from their historic character. In particular, if a building is listed on the national or local Historic Register, the mounting of solar collectors on the building may be restricted or prohibited.

Is your building of historic character?.....Yes or No

(6)

If it is, you should realize that visibility of collectors might be objectionable although several historic buildings including the White House, a Senate office building, and the Mount Rushmore Visitors Center have successfully installed active solar collection systems.

In designing solar collector systems for historic buildings particularly careful thought and planning are necessary to ensure that the system does not detract from the building's historic character and appearance.

Preliminary Shading

Access to direct sunlight is required for active solar collectors to operate efficiently. Some buildings, particularly those in urban areas, may have rooftop or ground areas which are heavily shaded by taller buildings, trees or other objects.

Is your building's roof area heavily shaded for most of the day?.....Yes or No

(7)

If it is apparent that sunlight does not consistently fall on any part of your roof or available ground area, you should skip the section on ACTIVE SOLAR OPPORTUNITIES, since active systems with collectors cannot be used. Go on to the section on PASSIVE SOLAR OPPORTUNITIES.

If you are uncertain about the seriousness of your shading problem, complete the section on ACTIVE SOLAR OPPORTUNITIES, since it includes a method to better evaluate the severity of your shading problem.

Structural Capacity

Active solar collectors and their supports usually weigh about 10 pounds per square foot. It is possible that your roof and building structure cannot accommodate such additional loading safely and in accordance with applicable building codes.

Can your building structurally support additional loading of 10 pounds per square foot?.....Yes or No

(8)

In many cases, you cannot be sure and should insist that a structural analysis be an early step in any future technical solar investigation beyond the scope of this Workbook.

"Sun Spot"
Periods of Occupancy

The term "regular" occupancy would describe a building which is used all year, at least 5 or 6 days per week, during normal working hours. Hospitals and most police stations would exceed those requirements, so they can be classified in the "regular" occupancy category. Schools which are operated all year (having athletic programs and summer school during most of the summer months) would also be "regular" occupancy.

The term "irregular" occupancy would describe buildings which have significant unoccupied periods. Schools which close summers, bath houses used only summers, or volunteer firehouses, would be classified in this category.

Periods of Occupancy

When considering possible solar options, it is very important to examine how long and how often your building is occupied, because use greatly influences solar economics. The more a building is used, the more attractive solar investments become, since the fuel is free and the equipment is always ready to work for you.

For the purposes of this Workbook, your building's occupancy should be classified as either "regular" or "irregular". See the "Sun Spot" on the opposite page for examples, and a discussion of building occupancies.

Decide which occupancy category best describes your building and then answer.

Is the occupancy of your building irregular?.....Yes or No _____ (9)

If your answer to Question 9 above is YES, please explain how your occupancy is irregular. _____ (Fill-In) (10)

For irregular occupancies, solar investments should be undertaken only after careful analysis in both this Workbook assessment and as part of any technical study beyond the scope of this Workbook, since your solar equipment may frequently go unused.

Summary

Before moving on, take a few moments to review your answers. Remember that some of them may advise you to either stop this preliminary solar investigation totally (as in the case of expected building life of less than 2 years), or to skip certain parts (such as the section on ACTIVE SOLAR OPPORTUNITIES if your roof or ground area is almost always in shade).

You are now ready to move on to the next section, where ACTIVE SOLAR OPPORTUNITIES will be explored.

Active Solar Opportunities

This section of the Workbook examines solar opportunities for which "active" solar components can be used.

Active solar energy systems include those which make use of factory or site fabricated collector units and distribute collected energy by mechanical means through the use of fans or pumps. Sometimes, such systems can be added to existing buildings (known as "retrofitting") to help provide for:

- Required hot water.
- Heating or cooling of spaces.
- Heating of outside air.
- Wind generation of electricity.

To evaluate the solar potential of your building(s) for active components and systems, this section is organized into the following three parts:

Hot Water

Almost all buildings need large quantities of hot water. After first determining if your needs are sufficient to merit installation of a solar hot water system, this part will evaluate the potential costs and benefits of a system to provide for 30% of your hot water needs (chosen for optimum system economics which will be explained later). Completing the hot water procedure will enable you to estimate the number of solar collectors required by such a system for your building(s).

Locating Collectors

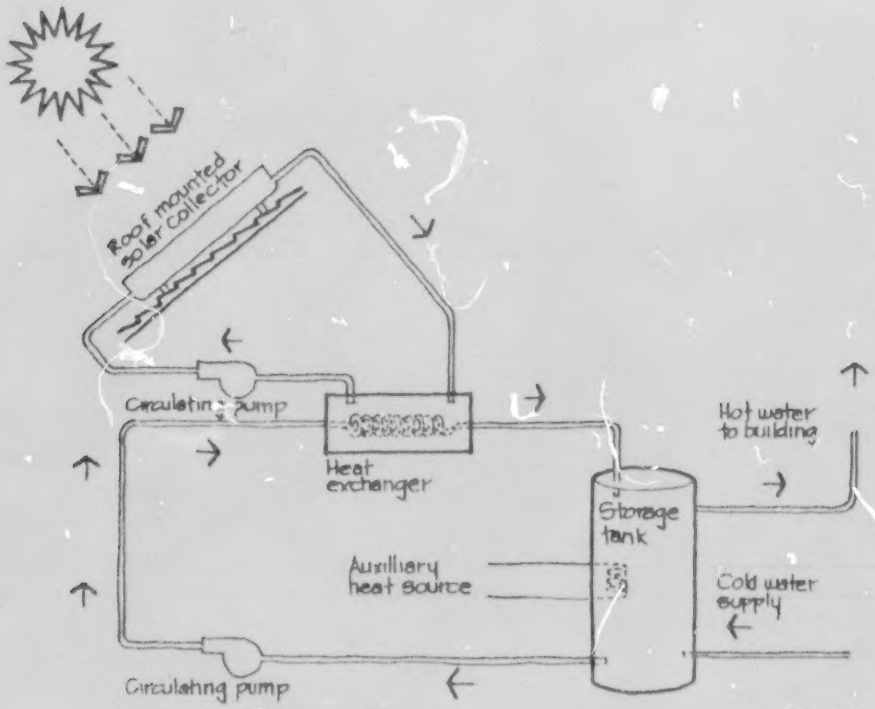
This part examines potential locations for the number of collectors identified in the previous part, and includes consideration of shading conditions.

Additional Options

As noted earlier, active components can be used to do much more than provide hot water. This part explores the various other solar options sometimes applicable to existing buildings, such as heating and cooling of spaces and wind generation of electricity.

"Sun Spot"
Typical Solar
Hot Water System

The diagram below shows the parts of a typical solar system to produce hot water.



Systems typically include solar collectors, circulating pumps, heat exchanger(s), storage tank(s), controls and an auxiliary heat source. Operation of the system begins at the collectors, where the sun's energy is collected and absorbed by a heat transfer fluid which is usually non-freezing and sometimes toxic. This heat transfer fluid is then piped to a heat exchanger where it gives off the acquired heat to water, piped to and from the hot water storage tank. Separate piping loops preserve the purity of stored water.

For typical uses, approximately 1.5 to 2.0 gallons of water per square foot of collector are required for storage. When solar energy is not available (or inadequate to meet demand), water is heated by an auxiliary heater using a conventional fuel, such as oil, gas or electricity.

Flat plate collectors are usually used for solar hot water systems (and have been assumed for the purposes of this Workbook) because of their efficient and cost-effective operation in the temperature range required (110 to 140 degrees F).

Introduction

Hot water heated by oil, gas or electricity, is needed by most buildings year-round. As the costs for these energy sources increase, the economics of solar-assisted hot water heating become more attractive.

The following procedure has been developed to evaluate the cost-effectiveness of an installation sized to provide for 30% of your building's year-round hot water needs. The 30% factor is used for this preliminary analysis because systems are usually not as cost-effective when designed to provide for a very large (closer to 100%) portion of year-round hot water needs. To meet a large percent of hot water needs in January (when there is less sun) the system might have to be so oversized that in July (when there is more sun) many of the collectors may be unneeded. A detailed analysis in the future may prove that a larger portion of your hot water needs (perhaps 50% to 75%) can be cost-effectively provided for by solar.

Upon completion of this part, you will know:

- Your hot water need in gallons per year.
- The number of collectors required to provide for 30% of this need.
- The approximate installed cost of an appropriate system including all its components.
- The dollars which may be saved by reducing your fuel or electrical consumption through using solar energy.
- The rate of return on your solar investment and simple payback.

Before beginning the analysis on the next page, you may wish to review the "Sun Spot" on the opposite page, which describes the components of a typical solar hot water system.

Example: Step 1
Yearly Hot Water Need

How much hot water does a multi-family housing project, with 50 apartments need?

Enter Consumption Factor (From Table I)..... 14,560

Multiply by (Number of Units of Measure)..... 50

Equals 728,000 Gallons per Year (11)

Table I .
Yearly Hot Water Consumption per Unit of Measure

SCHOOLS	
Elementary	120 Gals/Pupil
Day Care Facility	120 Gals/Child
Secondary or Vocation	350 Gals/Pupil
COLLEGES	
Administration	260 Gals/Employee
Classrodm Bldg	260 Gals/Av Daily Pupils
Library	310 Gals/Employee
Gym/Recr Bldg	1,560 Gals/Av Daily Showers
Cafeteria	1,560 Gals/Av Daily Hot Meals
Laboratory	1,560 Gals/Av Daily Pupils
Dormitory	4,730 Gals/Resident
OFFICES	
Off/Admin Bldg	260 Gals/Employee
Off/Admin Bldg w/Caf	1,800 Gals/Av Daily Hot Meals
HEALTH	
Clinic/Pub Health Ctr	4,680 Gals/Employee
Psy Fac/Nursing Home	6,720 Gals/Resident
Hospital	36,600 Gals/Patient Bed
CORRECTIONAL	
Admin	260 Gals/Employee
School	260 Gals/Pupil
Cell Block	4,730 Gals/Inmate
Gym/Recr Bldg	1,560 Gals/Av Daily Showers
Cafeteria	1,560 Gals/Av Daily Hot Meals
PUBLIC SERVICE	
Library	310 Gals/Employee
Police Station	1,450 Gals/Employee
Fire Station	2,190 Gals/Av Full Time Daily Emp
Maintenance Bldg	260 Gals/Employee
Maint Bldg w/Car Wash	7,200 Gals/Av Daily Veh Washes
Museum	2,600 Gals/Employee
HOUSING	
Multi-Family	14,560 Gals/Apartment
Halfway House/Comm Res	7,300 Gals/Resident

Step 1
Yearly Hot Water Need

The first item of information needed is your hot water consumption, which must be at least approximately 30,000 gallons of hot water per year to justify consideration of a solar hot water system.

If you know what your hot water needs are, fill in the value in Answer 11 and move on to Step 2. If you do not know what your hot water consumption is, use the following calculation to estimate it.

Obtain the appropriate value of "Yearly Hot Water Consumption per Unit of Measure" from Table I on the opposite page, which is based on average daily usages (average number of daily pupils, average number of daily employees, etc.) for various building types. If your building type is not listed, use the value for the building type most similar to yours.

Enter Consumption Factor
(From Table I)....._____

Multiply by (Number of
Units of Measure)....._____

Equals _____
Gallons
per Year (11)

Remember, if your total hot water need is less than 30,000 gallons, a solar hot water system will not be as good an investment for your building as for other buildings with larger hot water needs. If this is the case, the remainder of the section on ACTIVE SOLAR OPPORTUNITIES should be skipped. Move ahead in the Workbook to the section titled PASSIVE SOLAR OPPORTUNITIES.

Example: Step 2
Gallons of
Solar Hot Water

We can now obtain the number of gallons of hot water provided by a solar energy system contributing 30% of our hot water needs which were determined in Step 1 of our example.

Enter Answer 11
(Gallons of Hot Water per Year)..... 728,000

Multiply by
(Percentage Factor)..... .30

Equals 218,400
Gallons
from Solar (12)

Step **2**
Gallons of
Solar Hot Water

You can now determine how many gallons of hot water would be supplied by a solar energy system designed to provide 30% of your yearly hot water needs.

Enter Answer 11
(Gallons of Hot Water per Year)..... _____

Multiply by
(Percentage Factor)..... .30

Equals _____
Gallons
from Solar (12)

Example: Step 3
Number of
Collectors Required

Using the gallons of solar hot water (Answer 12) obtained in Step 2 of our example, the number of collectors required can now be determined.

Enter Answer 12
(Gallons of Solar Hot Water)..... 218,400

Divide by
(Production Factor)..... 7,820

Equals 28
Collectors

(13)

"Sun Spot"
Collectors

Obviously, not all collectors perform alike, nor is the amount of solar energy received by the different areas of New York State the same. For the purposes of this preliminary investigation, typical flat plate collector efficiencies have been assumed and constant weather data used. Use of these factors determines that an average collector will provide approximately 7,820 gallons of hot water per year, which has been called the "Production Factor". It has been assumed that a typical collector has 20 square feet of collection surface.

Step **3**
Number of
Collectors Required

The following calculation will determine how many collectors you require (round off your answer to the nearest number). See the "Sun Spot" on the opposite page for a discussion of the production factor and other collector considerations.

Enter Answer 12
(Gallons of Solar Hot Water)....._____

Divide by
(Production Factor).....7,820

Equals _____
Collectors (13)

Example: Step 4
Installed Cost

For our example, the installed system cost would be:

Enter Answer 13
(Number of Collectors)..... 28

Multiply by (Total System Cost
per Collector from Table II)..... $1,275

Equals $ 35,700
Dollars

(14)

Table II
Collector Costs

Number of Collectors Required	Total System Cost
2.....	$1,275 per Collector
3 to 4.....	$1,050 per Collector
5 to 8.....	$1,100 per Collector
9 to 20.....	$1,375 per Collector
21 to 35.....	$1,275 per Collector
26 to 49.....	$1,175 per Collector
50 or more.....	$1,050 per Collector

The costs for systems which require only 2, 3 or 4 collectors are based on prepackaged systems, while systems requiring 5 to 8 collectors may be either prepackaged from some manufacturers or require some custom design. For larger systems, custom design will be required, which results in generally higher unit costs unless a large number of collectors are required.

Costs shown are in late 1979 dollars and are total installed costs which include equipment and labor.

Step 4
Installed Cost

The installed cost of a solar hot water system is dependent upon many variables including site conditions, cost of collectors, size of installation, need for new equipment, length of pipe runs, and need for structural work and supports. In addition to these variables, normal fluctuations of construction materials and overhead and profit may make preliminary estimation of solar system cost difficult. Nevertheless, for the purposes of this preliminary study, it can be assumed that the installed system cost will approximate the values shown in Table II on the opposite page, based upon the number of collectors required.

Enter Answer 13
(Number of Collectors)....._____

Multiply by (Total System Cost
per Collector from Table II)....._____

Equals $_____
Dollars (14)

Example: Step 5
Yearly
Dollar Savings

Let's see what the dollar savings per year would be for our example building if it heats water with electricity at $0.09 (nine cents) per kilowatt hour.

Enter Electric Price per Kilowatt Hr.... .09

Multiply by Answer 12
(Gallons of Solar Hot Water)..... 218,400

Multiply by
(Heat Conversion Factor)..... .15

Equals $ 2,948
Dollars

(15)

"Sun Spot"
Heat Conversion
Factors

In each calculation, the heat conversion factor represents the capacity and thermal efficiency of a unit of fuel (i.e. kilowatt hour of electricity, gallon of oil, or cubic foot of gas) in heating a gallon of water.

For example, the factor of .15 for electricity results from dividing 500 (the number of BTU's required to heat a gallon of water from 50 degrees to 110 degrees F.) by 3,413 which is the effective number of BTU's delivered per kilowatt hour. Similarly, for gas .71 represents 500 divided by 700 (the effective number of BTU's per cubic foot of gas) and .005 for oil represents 500 divided by 100,000 (the effective number of BTU's per gallon of oil).

"Sun Spot"
Fuel Costs

Perhaps your fuel costs vary over the course of the year. For example, you may pay different rates during summer and winter. If so, you should average together representative bills.

Your electrical rate should be calculated by dividing the total dollar amount billed by the number of kilowatt hours used. By this method you will also be including a proportional amount of any demand charges based upon overall quantities of electricity required. When you do the calculations, be sure to remember that you should multiply by a number such as .05 (for five cents) or .08 (for eight cents).

Step 5
Yearly
Dollar Savings

To assess the yearly economic benefits from a solar installation providing energy for 30% of your hot water needs, you must first determine your cost to obtain that energy.

To do this, use the calculation appropriate for the energy source (electric, gas or oil) you now use to heat water, and fill in your current cost. See the "Sun Spot" on the opposite page for information on heat conversion factors and fuel costs.

Electricity

Enter Electric Price per Kilowatt Hr.... _____

Multiply by Answer 12
(Gallons of Solar Hot Water)..... _____

Multiply by
(Heat Conversion Factor)..... .15

Equals $ _____
Dollars (15)

Gas

Enter Gas Price per Cubic Foot..... _____

Multiply by Answer 12
(Gallons of Solar Hot Water)..... _____

Multiply by
(Heat Conversion Factor)..... .71

Equals $ _____
Dollars (15)

Oil

Enter Oil Price per Gallon..... _____

Multiply by Answer 12
(Gallons of Solar Hot Water)..... _____

Multiply by
(Heat Conversion Factor)..... .005

Equals $ _____
Dollars (15)

Example: Step 6
Economic Analysis

For our example, the economic calculations would be:

Rate of Return:

Enter Answer 15
(Yearly Dollar Savings)..... $2,948

Divide by Answer 14
(Installed Cost)..... $35,700

Multiply by
(Conversion Factor)..... 100

Equals 8.25 %
Percent

(16)

Simple Payback:

Enter Answer 14
(Installed Cost)..... $35,700

Divide by Answer 15
(Yearly Dollar Savings)..... $ 2,948

Equals 12.1
Years

(17)

"Sun Spot"
Solar Investments

A solar hot water system investment requires a cost/benefit analysis in order to assess economic advisability. Step 6 calculates rate of return (percent of total investment returned each year) and simple payback (number of years required to repay total investment). You should use these results to determine if the returns on investment offered project a favorable investment based upon the various economic determinants for your building. Remember, however, that Answers 16 and 17 reflect benefits at current fuel costs. Actual paybacks and returns on investment are likely to be much more attractive if fuel costs continue to escalate as they have for the last few years. Also, remember that an investment in solar energy is paid back not only in dollars, but in a cleaner environment and lessened dependence on foreign energy sources as well.

Step **6**
Economic Analysis

Calculations can now be made to determine rate of return and simple payback on a 30% solar hot water system for your building(s). After doing the calculations, you may wish to read the "Sun Spot" on the opposite page for a discussion of aspects of solar investments.

Rate or Return:

Enter Answer 15
(Yearly Dollar Savings)....._____

Divide by Answer 14
(Installed Cost)....._____

Multiply by
(Conversion Factor)....._____

Equals _____ %
Percent (16)

Simple Payback:

Enter Answer 14
(Installed Cost)....._____

Divide by Answer 15
(Yearly Dollar Savings)....._____

Equals _____
Years (17)

Possible Revisions

The next section of this Workbook examines possible active solar collector mounting locations for your building(s). Some of these locations will result in lower or higher average installation costs and thus, different economic benefits than those just calculated in Step 6. Completion of Step 7 will account for any necessary adjustment. However, you will only know whether to use Step 7 after completion of the next part of this Workbook. Skip Step 7 for now and go on to the part which locates collectors.....you will be told if, and when, you should come back to Step 7.

Example: Step 7
Revised
System Economics

Because our example building has an optimally-oriented south-facing sloped roof with adequate space for collector mounting, we have been referred back to this Step to revise our economic calculations.

Revised Calculations for
Optimally-Oriented Sloped Roofs

Revised Rate of Return:

Enter Answer 16 (Rate of Return)..... 8.25 %

Multiply by (Cost Factor Modifier)..... 1.10

Equals 9.08 %
Percent

(16r)

Revised Simple Payback:

Enter Answer 17 (Simple Payback)..... 12.1 years

Multiply by (Cost Factor Modifier)..... .90

Equals 10.9
Years

(17r)

System economics are revised similarly (using the other set of calculations) for those buildings where ground mounting of collectors is required.

Step 7
Revised
System Economics

Now that you have been referred back to this step, use one of the following calculations to revise your economic analysis as appropriate for your collector mounting location.

Revised Calculations for
Optimally-Oriented Sloped Roofs

Revised Rate of Return:

Enter Answer 16 (Rate of Return)..... _____ %

Multiply (Cost Factor Modifier)..... 1.10

Equals _____ %
Percent (16r)

Revised Simple Payback:

Enter Answer 17 (Simple Payback)..... _____ years

Multiply by (Cost Factor Modifier)..... .90

Equals _____
Years (17r)

Revised Calculations for
Ground-Mounting of Collectors

Revised Rate of Return:

Enter Answer 16 (Rate of Return)..... _____ %

Multiply by (Cost Factor Modifier)..... .90

Equals _____ %
Percent (16r)

Revised Simple Payback:

Enter Answer 17 (Simple Payback)..... _____ years

Multiply by (Cost Factor Modifier)..... 1.10

Equals _____
Years (17r)

"Sun Spot"
Solar Collection Hours

Collection of solar energy for active systems is best during midday about three hours before and after solar noon. During such periods the collectors should "see the sun" and not be shaded for significant periods by surrounding buildings, trees or other objects.

Keep in mind that solar time differs from the time on our watches and clocks. This is because the sun will "rise" in Montauk Point almost one-half an hour before it does in Buffalo, although they are in the same time zone, and also because at times during the year we adopt daylight savings time to shift the period of daylight to better suit our needs and lifestyles. Despite these factors, it should be understood that the sun is above the east and west horizons for a given period each day and at the halfway point is to the south (solar south), which occurs at what is known as "solar noon". You can determine the time of solar noon from your local newspaper by figuring out the time halfway between sunrise and sunset. At that time, the sun is solar south.

Introduction

Now that you have determined how many collectors might be required to provide for 30% of your hot water needs, this part of the Workbook will assist you in evaluating potential locations for those collectors. Collector locations must be of adequate size and generally free of shading from surrounding buildings, trees or other objects.

See the "Sun Spot" on the opposite page for information on the prime collection hours during which direct sunlight is most beneficial.

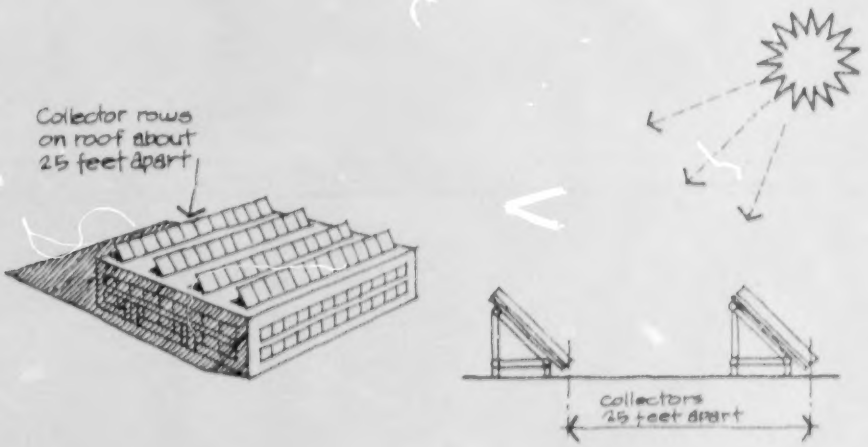
Organization

This part of the Workbook is arranged as follows:

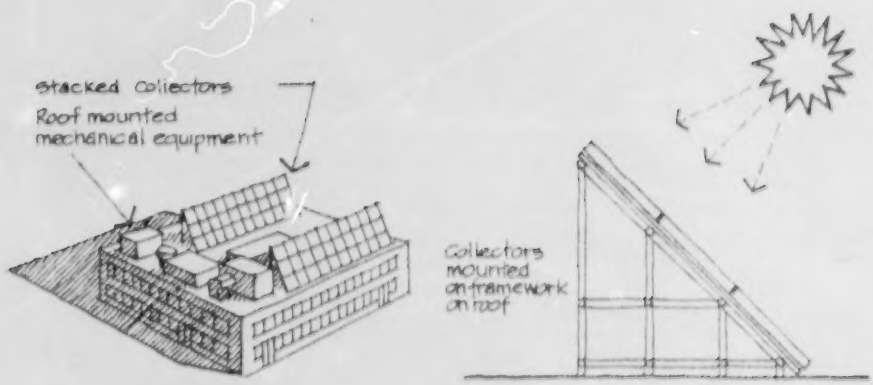
- STEP 1 evaluates flat roofs for collectors. If you have a flat roof, you should start with this step.
- STEP 2 investigates sloped roofs for collectors. Start here if this is your situation.
- STEP 3 considers site areas as possible locations for ground mounting collectors. This step should be taken only if Step 1 and Step 2 indicates that roof mounting of collectors is not possible for your building.
- STEP 4 examines potential shading conditions at the location where your collector would be mounted.

Turn now to either Step 1 if you have a flat roof, or Step 2 if your roof is sloped. If you have both flat and sloped roofs, check out each by completing Steps 1 and 2 if it is not apparent which is most suitable for an active solar installation for your building.

Single Row Mounting of Collectors on Flat Roofs



Stacked Mounting of Collectors on Flat Roofs



Step 1
Flat Roofs

If your building has one or more flat roofs, there are two fundamental questions which need to be answered:

- How much roof area is required for collectors?
- Where on the roof should the collectors be located?

Required Roof Area

Active solar collectors can be roof-mounted on flat roofs in either single rows or in a stacked arrangement as shown in the sketches on the opposite page. The following calculations will help you determine approximately how much roof area is required for each type of mounting. The Area Factor represents the approximate square footage of roof area required for each collector to avoid shading of one collector by another.

Single Row Mounting Area Required:

Enter Ans. 13 (No. of Collectors)..... _____

Multiply by (Area Factor)..... 80

Equals _____
Square Feet (18)

Stacked Mounting Area Required:

Enter Ans. 13 (No. of Collectors)..... _____

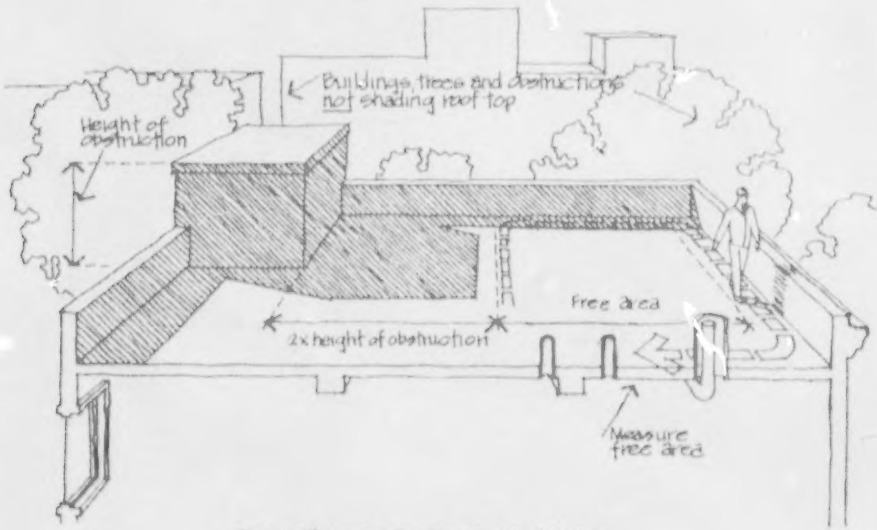
Multiply by (Area Factor)..... 15

Equals _____
Square Feet (19)

Collector Location

Solar collectors must be located on roofs which are basically unshaded and which have adequate area for the collector uncluttered by rooftop equipment or structures. Whenever possible, collectors should also be located as close as possible to mechanical rooms to shorten lengths of pipes. If your building has more than one flat roof, select the one which is most likely to satisfy these criteria.

Determination of
Available Roof Area
by Pacing-Off


Buildings, trees and obstructions not shading roof top
Height of obstruction
Free area
2x height of obstruction
Measure free area

BUILDING CUTAWAY VIEW
SHOWING ROOFTOP

Now that the required area for each type of mounting (single rows or stacked) is known, go to your roof and select your best mounting location, as follows:

1. Look for any buildings, trees or other objects to the south, taller than your building, which may shade your roof area. If there are none, then you can mount collectors on any part of the roof. If shading seems to be a problem, find the area on your roof which is likely to be sunniest (near the north edge of the building's roof).

2. Determine if you have enough area to install collectors in single row mounting. Take Answer 18 and think of it as a two-dimensional area (length times width). For example, if Answer 18 is 1,200 square feet of roof area, this could be an area 20 feet x 60 feet, or 30 feet x 40 feet.

3. Look at your roof to see if such a free area is available. In most cases, it will probably be clear that you have an area more than large enough for collector mounting in single rows. If you aren't sure, measure the area available with a tape or approximate it by pacing off the area. Do not include any areas which might be shaded by existing rooftop items, such as stairs or mechanical equipment. This can be assured by not including in your measurements any area on the north side of such items for a distance equal to twice their height. See the sketches on the opposite page for an illustration of this approximation method.

4. Answer the following:

Do you have adequate flat roof area for collectors mounted in single rows?.....Yes or No

(20)

If your answer to Question 20 is YES, go on to Step 4 to examine shading conditions for that location. If your answer is NO, go on to the next page to investigate your roof area for stacked mounting of collectors.

Stacked mounting of collectors requires less area. To determine if your roof area is large enough for such mounting, complete the following steps.

1. Think of Answer 19 (the area needed for stacked collectors) in terms of a two-dimensional area (length times width).

2. Look at your roof to see if such a free area is available. If necessary, measure the area available with a tape or approximate it by pacing off the area. Do not include any areas which might be shaded by existing rooftop items, such as stairs or mechanical equipment. This can be assured by not including in your measurements any area on the north side of such items for a distance equal to twice their height. See the sketches on Page 38 for an illustration of this approximation method.

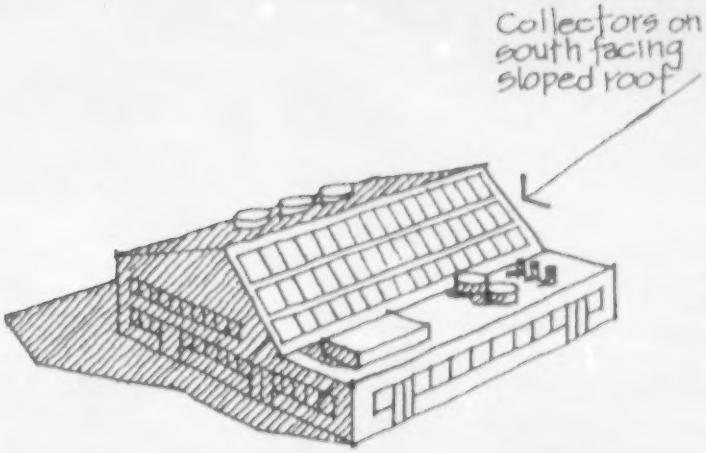
3. Answer the following:

Do you have enough area for
collectors in stacked mountings?.....Yes or No

(21)

If your answer to Question 21 is YES, go on to Step 4 to examine shading conditions for that location. If the answer to Question 21 is NO, go on to Step 3 where potential ground mounting of the collectors will be investigated.

Collector Mounting
on South-Facing
Sloped Roof



Step 2
Sloped Roofs

For buildings with sloped roofs, the following factors must be examined:

- Size of roof
- Orientation of roof
- Angle of roof

Size of Roof

If you have a sloped roof which generally faces south, you must determine if it is large enough to accommodate the number of collectors (Answer 13) required by the hot water procedure. For sloped roofs, actual roof area and possible collector mounting area are about equal, since collectors are mounted flat or nearly flat on the sloped roof surface.

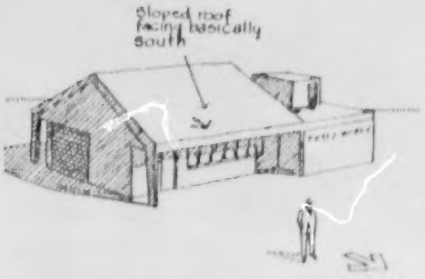
Therefore, approximate or measure your south-facing roof area to answer Question 22. Remember that the area required for collectors is Answer 13 multiplied by twenty (20), the assumed area of a typical collector.

Is your sloping roof area larger than the area required for collectors?.....Yes or No

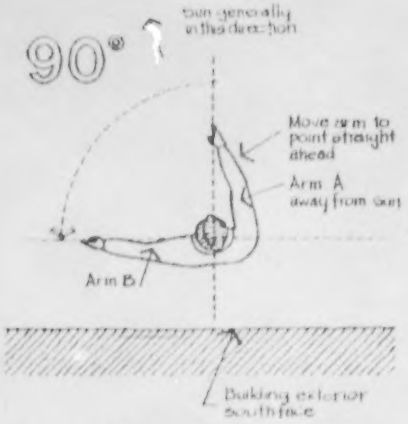
(22)

If the answer to Question 22 is YES, continue on in this Step 2 to investigate roof orientation and angle. If, however, space is inadequate and the answer to Question 22 is NO, skip to Step 3 where site areas for ground-mounting of collectors are considered.

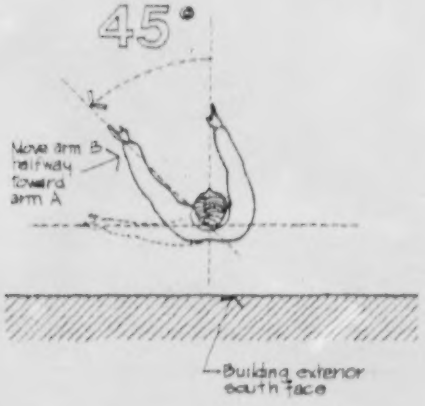
Roof Orientation
by Arm Method



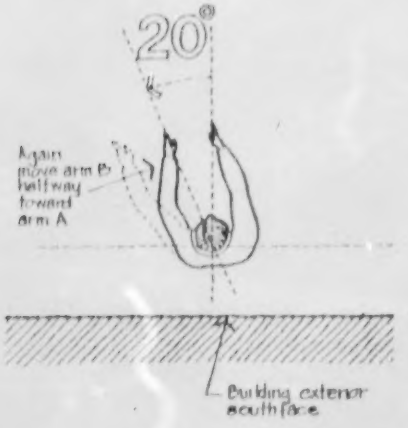
Step 1



Step 2



Step 3



Step 4

Step 5

Step 5

Orientation of Roof

Sloped roofs should face within approximately 20 degrees of south for an efficient and economical installation of solar collectors. There are several ways to determine if your sloping roof is adequately south-facing:

- You can use a magnetic compass; however, the fact that magnetic south is about 10 degrees to the east of solar south in New York State must be taken into account.
- You can look at a set of building plans, if available. Remember to adjust for magnetic south as stated above.
- You can use the arm method which follows and which is also shown in the sketches on the opposite page. You may find it helpful to complete this procedure with someone else's help; they can read the directions as you follow the steps.

Arm Method:

STEP 1: On a sunny day at noon (or 1:00 p.m. daylight savings time) stand on the ground with your back to your building and face in the same direction as your sloped roof.

STEP 2: Point straight ahead with your arm which is away from the sun (Arm A). Extend your other arm straight out from your shoulder (Arm B).

STEP 3: Now, move Arm B halfway toward Arm A, so that there is about a 45 degree angle between your arms.

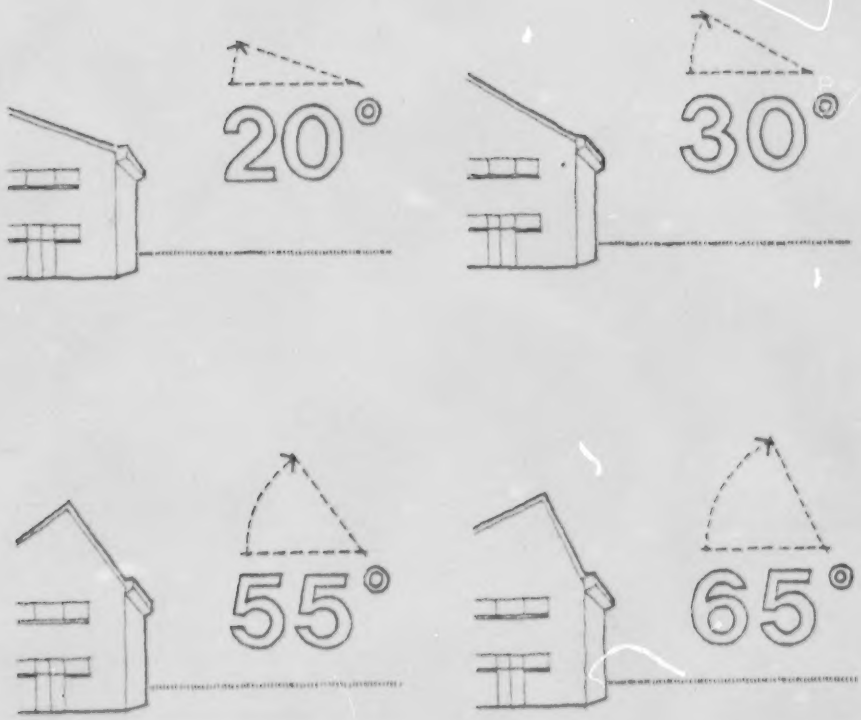
STEP 4: Again, move Arm B halfway through the remaining distance toward Arm A. The angle formed (about 22½ degrees) is close enough to the 20 degree angle we are checking.

STEP 5: Raise both arms straight upward without changing the angle between them, until you can tell if the sun is between your uplifted arms. If it is, then your roof, which is behind you, adequately faces south.

"Sun Spot"
Sun Angles

Because of sun angles and the desirability for year-round system operation, collectors for solar hot water systems are best mounted at an angle to the ground which is within 10 degrees of equal to the latitude. Latitudes in New York State range from about 40 degrees north latitude in the southernmost part of the State near New York City, to about 45 degrees in the northern part of the State near Plattsburgh. Therefore, where roof slope is between 30 and 55 degrees, collectors will perform at good efficiency when mounted at the same angle as the roof.

Roof Angle Diagrams



Now that you have checked your roof orientation, answer the following question.

Does your sloping roof adequately face south (within about 20 degrees)?.....Yes or No

(23)

If your answer to Question 23 is YES, continue with this step to investigate the angle of your sloped roof. If, however, your answer to Question 23 is NO, you should skip to Step 3, where ground-mounting of collectors on site areas is considered.

Angle of Sloped Roof

For collectors to perform efficiently, they should slope at an angle to the ground of between 30 and 55 degrees. See the "Sun Spot" on the opposite page.

To determine the slope of your roof, check a set of building plans if you have them available. If plans are not available, stand far enough away from your building so that you can see the roof in profile. Then look at the various roof angle diagrams on the opposite page. Look back and forth at your roof and the diagrams until you are sure which angle is closest to yours.

Does your roof slope at an angle between 30 and 55 degrees?.....Yes or No

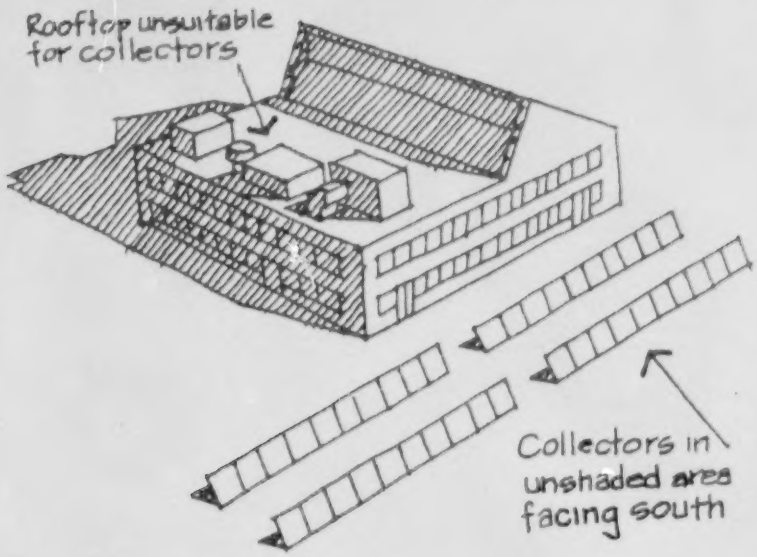
(24)

Next Steps

If you have answered YES to all three questions in this part (22, 23 and 24), then your sloped roof is of a size, orientation and angle which is likely to result in lower than average collector support costs. Go back to Step 7 of the HOT WATER PROCEDURE (Page 33) to calculate revised system economics. After revising your economics in Step 7 of the HOT WATER PROCEDURE, come back to Step 4 of this part on LOCATING COLLECTORS to evaluate shading conditions.

If you have answered NO to Question 24, turn the page and follow Step 3 where site areas for ground-mounting of collectors are considered.

Collector Mounting on Site Areas



Step 3
Site Areas

Perhaps you have determined from either Step 1 or Step 2 that certain factors such as roof size or orientation have eliminated the possibility of roof-mounting the collectors. If this is the case, it may be possible to ground-mount the collectors on an unshaded site area which is large enough. If you think that you may have such an area, you should examine it as if it were a flat roof (review procedures of Step 1 on Pages 37 through 41), and then answer the following:

Do you have enough site area with unshaded southern exposure to ground-mount the solar collectors required by the hot water procedure?.....Yes or No

(25)

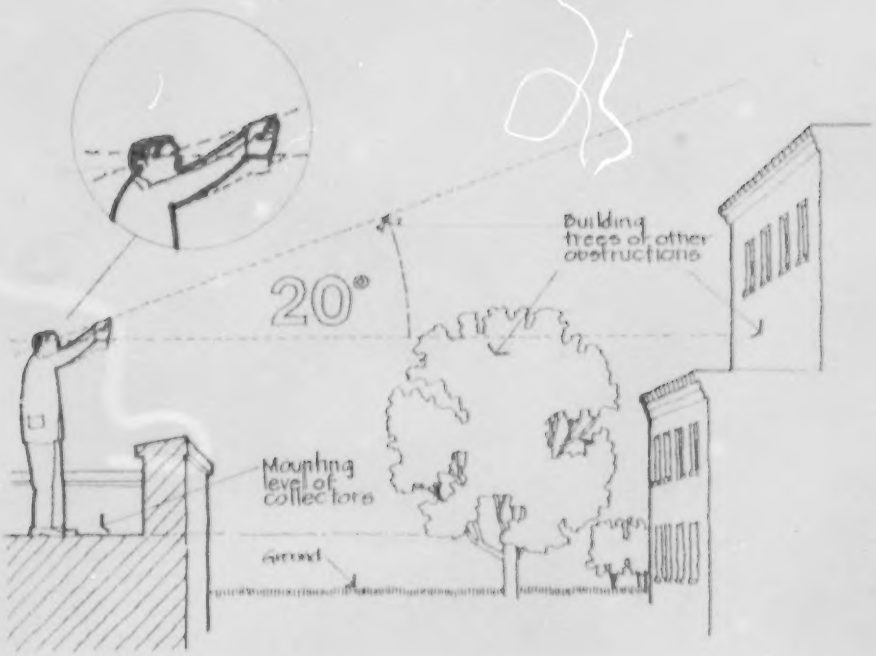
Results

If, after answering NO to Question 22, 23 or 24, your answer to Question 25 is also NO, then you have determined that you have no available mounting locations for solar collectors, and an active solar energy system cannot be installed. If this is the case, go on to the section on PASSIVE SOLAR OPPORTUNITIES.

If your answer to Question 25 is YES, then ground-mounting of collectors on your site will allow you to install a system. Unfortunately, such mounting is usually more expensive than rooftop mounting. To allow for this, go back to Step 7 of the HOT WATER PROCEDURE (Page 33) to determine revised system economics. After you have revised your economics in Step 7 of the HOT WATER PROCEDURE, come back to Step 4 of this part on LOCATING COLLECTORS to evaluate shading conditions.

Shading Conditions
by Arm Method

Step 1



Step 2

Step 4
Shading Conditions

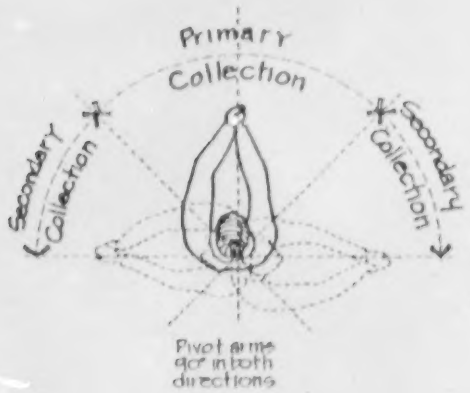
For efficient operation, active solar collectors need to receive direct sunlight for most of the daylight hours. Therefore, you must investigate the area to the south of where your collectors would be mounted for possible shading conditions from tall buildings, trees or other objects.

Determination of shading conditions can be very complicated, requiring the use of sun angle diagrams, a protractor, a compass, and drafting equipment. For your preliminary purposes, however, a simple method based upon human proportions can be used to evaluate your shading conditions. As described below and as shown in the sketches on the opposite pages, two fists are assumed to equal 20 degrees. By scanning the sky at heights of both two and three fists, you can estimate if shading conditions are slight (two fists) or serious (three fists).

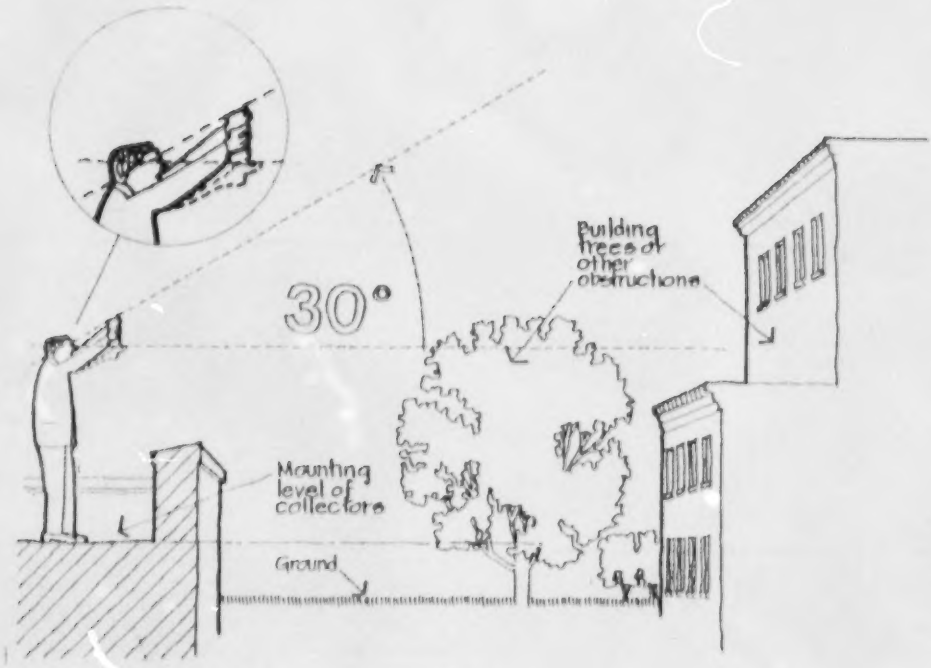
To use the simple method illustrated on the opposite page, go to the roof or ground area where your collectors would be mounted and follow the steps shown below. If you have a sloped roof, follow this procedure from a location as close as possible to the sloped roof being examined. For example, this might be a top floor window directly below the roof surface being considered.

STEP 1: Conduct this investigation on a sunny day at noon (or 1:00 p.m. daylight savings time). Face the sun so that you are looking south. Point straight ahead with the index finger of your right hand (as shown in the sketch) so that the line between your eyes and your extended finger is parallel to the roof or ground.

STEP 2: Now make a fist with your left hand (thumb on top) and place it on top of your extended right hand. Hold your left hand steady and make a fist in the same way with your right hand and place it upon your extended left fist. You now have an extended two-fist height which should approximate a 20-degree angle.


Primary Collection
Secondary Collection
Secondary Collection
Pivot arms 90° in both directions

Step 3


30°
Building trees or other obstructions
Mounting level of collectors
Ground

Step 4

STEP 3: Without moving your feet, pivot your arms 90 degrees in each direction, so that you will be scanning between east and west and, in particular, between the primary collection directions of southeast to southwest (see sketch). If you see nothing but sky, you have no shading problems and can mount your collectors at that location without concern.

If, however, you can see any buildings, trees, or other objects above this two-fist height, these items might cause at least a slight shading condition.

STEP 4: To determine if this condition may be serious, repeat the procedure, only this time use three fists to approximate a 30-degree angle. If you cannot see the sky over three fists for most of the swing between east and west, then you might have a serious shading problem.

Be sure that you have studied the sketch and have done this examination carefully. Because this method is only approximate, repeat it several times. Record your results by answering the following:

Did you learn from Step 3 that you might have a slight shading problem?.....Yes or No

(26)

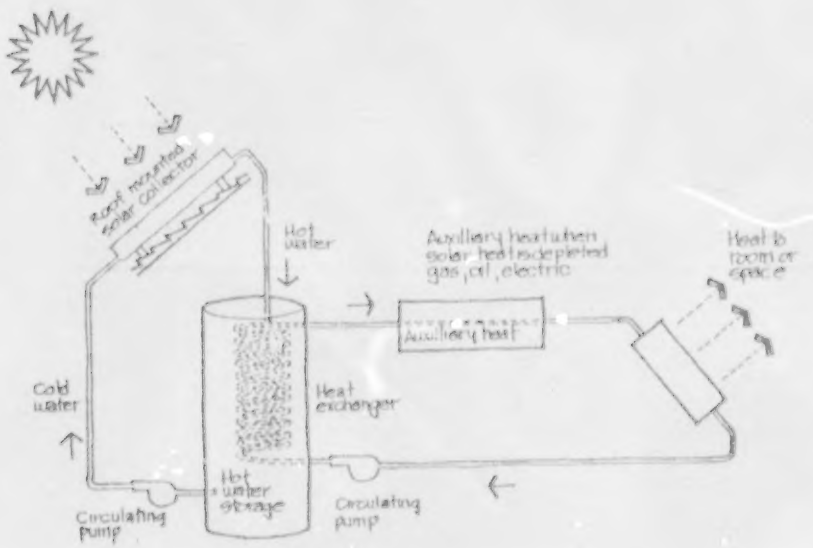
Did you learn from Step 4 that you might have a serious shading problem?.....Yes or No

(27)

If you have answered YES to Question 27, you may have difficulty in finding adequate unshaded roof or ground area upon which to mount collectors. In such cases, a detailed shading study should be completed as the first step of any further investigation for an active solar system.

"Sun Spot"
Systems to
Heat Spaces

Shown below is a solar heating system with liquid-type collectors.



The system begins when solar heat is absorbed by the collectors and transferred to a non-freezing liquid passing through the collectors. This solar-heated liquid is then sent to a tank for storage or to a heat exchanger for heat transfer to the distribution loop. An insulated water storage tank is used for storing excess heat energy. An auxiliary energy source is required to provide energy when the sun is unavailable and stored energy has been depleted.

Systems with air-type solar collectors are also available for use when they are more compatible with the existing equipment. Air systems usually use rock bins for storage of collected energy.

Introduction

In addition to systems for hot water, there are several other ACTIVE SOLAR OPPORTUNITIES which may apply to your building, including:

- Systems to heat spaces.
- Systems to cool spaces.
- Heating of outside air.
- Wind generation of electricity.

It should be noted that most of these options are not as applicable, nor as cost-effective for most existing buildings as a solar hot water system. Nonetheless, the basic questions asked in this part of the Workbook will help to indicate if your building may be a uniquely promising candidate for their consideration. Also remember that an energy-efficient, well-insulated building is necessary if you are going to effectively use solar energy to heat or cool the interior spaces of your building.

Heating of Spaces

Different types of solar systems can be used to heat spaces depending upon the type of heating system. For systems based on hot water or steam, either a liquid-type flat plate collector or some type of concentrating collector would be required, depending upon needed temperatures. Flat plate solar collectors are normally used with hot water heating systems which operate at temperatures of 100 to 140 degrees F. Concentrating collectors are used when higher temperature water or steam is needed for the heating system. A typical system using flat plate liquid collectors is described in the "Sun Spot" on the opposite page.

Answers to the following questions will help to determine whether your building may be suitable for installation of an active solar space heating system. Fill in the appropriate letter(s) for each answer and describe any answers which are not among the listed choices.

What type of space heating system does your building have?.....Type_____

(28)

TYPE A - Hot Water Boiler
TYPE B - Steam Boiler
TYPE C - Heat Pump
TYPE D - Hot Air Furnace
TYPE E - Other (fill-in)

What is the typical terminal heating unit in the spaces of your building?.....Type _____

(29)

TYPE A - Air Outlet
TYPE B - Air to Air Heat Pump
TYPE C - Finned Tube Radiation
TYPE D - Water to Water Heat Pump
TYPE E - Cast Iron Radiator
TYPE F - Unit Heaters
TYPE G - Electric Baseboard Heat
TYPE H - Other (fill-in)

What type of heating fuel does your building use?..... _____
(Fill-In)

(30)

Solar space heating systems for existing buildings are frequently not cost-effective because the solar equipment is only used for part of the year (during the heating season) and modifications to existing heating systems tend to be costly. Nevertheless, an investigation of solar space heating potential should be included in any future technical investigation beyond the scope of this Workbook.

Cooling of Spaces

Cooling with solar energy generally requires high temperature or concentrating collectors, along with absorption cooling machines.

Does your building provide for its cooling needs by using absorption machines?.....Yes or No _____

(31)

If the answer is YES, then solar cooling is a solar potential which should be considered in any future technical investigation beyond the scope of this Workbook. Since New York State has a relatively short cooling season, the economics of such a system should be carefully analyzed.

Outside Air

Many buildings such as laboratories and health facilities require frequent changing of air to maintain freshness and to remove contaminants. In order to control temperatures in such spaces the outside air must generally be heated before being introduced into the interior space. If large enough quantities of heated air are required for long periods of operation, the economics of a solar energy system to fulfill this need may be attractive.

Is your building a laboratory, health-related facility or other building which requires large quantities of outside air?.....Yes or No

(32)

If the answer is YES, have this option studied in any future technical solar investigation beyond the scope of this Workbook.

Wind Generation

Wind is a solar source which has great electricity generation potential, particularly in areas with high average wind speeds and high electricity rates from utilities. Although wind power is not yet a common solar form, many ground-mounted generators exist. Some generators have been installed on rooftops, although such mountings must be carefully studied because of turbulence above roof surfaces and stresses on roof structures.

Small wind generators, for good performance, are best mounted at least 40 feet above the ground on a site area which is generally unobstructed for at least 300 feet around in all directions. The higher above the ground the wind generator is mounted, the greater the energy return will be. Generally, a minimum average wind speed of 12 miles per hour at wind turbine height is recommended.

Do you have a sufficiently large open site exposed to your region's prevailing winds for a wind generator?.....Yes or No

(33)

If your answer is YES, then wind generation of electricity is an option which is likely to become more favorable as electrical rates increase and as wind technology and products become more readily available.

Passive Solar Opportunities

Introduction

Passive solar systems collect, transport or use solar energy without relying on outside energy sources for operation. Generally, passive systems rely upon building or site design to directly utilize the available solar energy or reduce energy needs. As such, the passive options available for existing buildings are limited, since major redesigns and resultant construction costs may be prohibitive. Several passive systems which may be applicable to your existing building are:

- Daylight
- Isolated Gain
- Indirect Gain
- Direct Gain
- Landscaping

To discuss these passive systems, this section has been organized into the following two parts.

Daylight

Available daylight can be used to supplement or replace the electric lights near windows, while maintaining the level of required illumination. The daylight procedure will evaluate the potential of buildings with fluorescent fixtures to utilize available daylight. This procedure will also include a cost-benefit analysis.

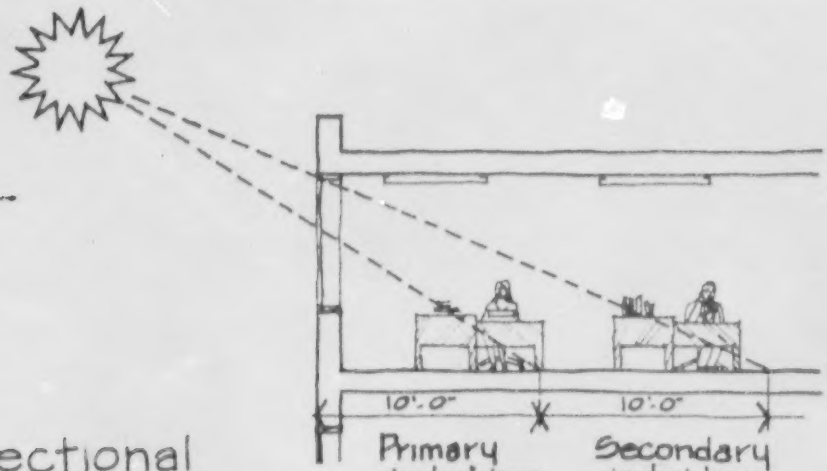
It should be noted that the daylight procedure is limited to fluorescents, since these types of fixtures are reasonably efficient, easily modified and tend to be the primary type of fixtures near windows (known as perimeter lighting). If your building has incandescent fixtures for perimeter lighting, similar options exist, although they may not be as economical. In these cases, replacement of incandescent fixtures with more efficient fluorescents should also be considered.

Additional Options

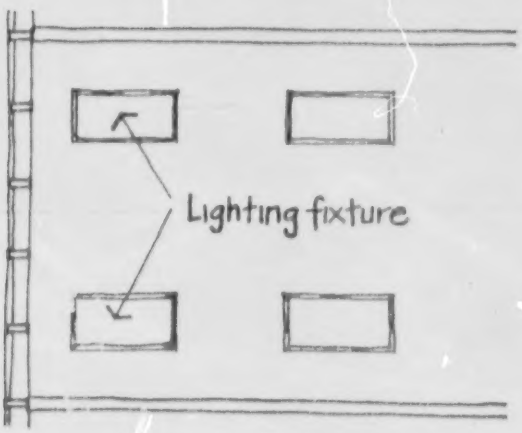
The passive systems of isolated, indirect and direct gain can provide for large portions of a building's energy needs. Proper landscaping can also affect building energy performance significantly. This part of the Workbook will describe these systems and examine their potential.

Now turn to the next page to see if you can take better advantage of available daylight in your building.

Evaluation of
Daylighting Zones



Sectional View



Ceiling Plan

Introduction

If your building has fluorescent lighting fixtures near window areas (within about 10 feet), daylight can frequently be used to provide for a portion of your lighting needs.

By dimming these fixtures you can utilize available daylight. This is accomplished using a system consisting of a photo-electric sensor mounted below the fixture, a dimmer with controls, and appropriate dimming ballast. The sensor measures available daylight and dims the output (and energy use) of fluorescent tubes as much as possible, while maintaining the same lighting levels as in an adjacent space where fluorescent tubes are operating at full capacity. Installation of the required dimming equipment is relatively inexpensive since it can usually be accomplished on an individual fixture and requires no rewiring of existing circuits.

To help determine if your building can benefit from this form of passive solar energy, this procedure will examine:

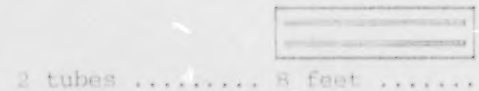
- Potential energy and dollar savings.
- Cost of installation.
- Rate of return and simple payback.

To familiarize yourself better with the daylighting concept being investigated, see the sketch on the opposite page before turning to the next page to begin the procedure.

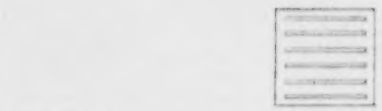
Table III
Watts per
Typical Fixture

2 tubes ..... 4 feet ..... 92 watts

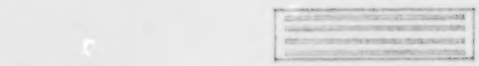
4 tubes ..... 4 feet ..... 184 watts



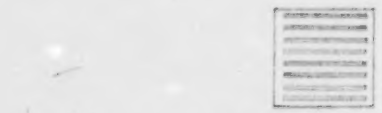
2 tubes ..... 8 feet ..... 184 watts



6 tubes ..... 4 feet ..... 276 watts



4 tubes ..... 8 feet ..... 368 watts



8 tubes ..... 4 feet ..... 368 watts

Table based on 430 milliamp lamps and ballast.

Step 1
Watts per
Typical Fixture

Using Table III on the opposite page, identify the type of fluorescent lighting fixture found within about 10 feet of your building's windows.

If your building has several different types of fluorescent lights near windows, you should complete this procedure separately for each fixture type, since the economics are slightly different for each. To do this, you may wish to make copies of the pages of the daylight procedure (Steps 1 through 8) before beginning.

Enter the number of watts which this type of fixture uses (from Table III)....._____
Watts (34)

Example: Step 2
Hours of Operation

If a school is open 5 days a week for only 40 weeks a year from 8:00 a.m. until 4:00 p.m., how are the "hours of daylight operation" calculated?

Calculation:

5	days per week
x 40	weeks per year
200	days per year
x 8	hours per day
1600	hours of daylight operation per year

Fill in your total of daylight hours of operation over a one-year period..... 1600 Hours (35)

Use a similar method for your building if occupancy is different than normal working hours

Table IV
Hours of Operation

Period of Occupancy	Daylight Operation
Every Day All Year.....	3,500 Hours
6 Days a Week All Year.....	3,000 Hours
5 Days a Week All Year.....	2,500 Hours

Step **2**
Hours of
Operation

You must now determine how many daylight hours during the year your fluorescent fixtures are being used. Obtain this answer from Table IV, which is based on daylight periods of occupancy for 9.5 hours per day.

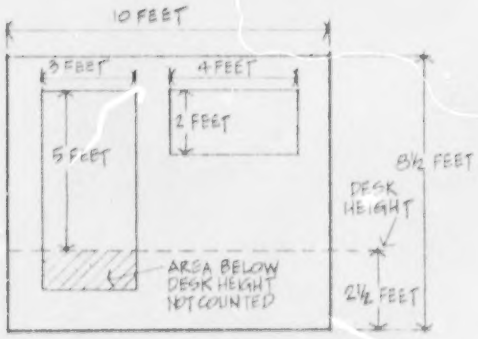
If your building does not operate during these working hours, or if it is not used during parts of the year, see the example on the opposite page for a method to approximate your hours of operation.

Fill in your total of daylight hours of operation over a one-year period....._____
Hours

(35)

Example: Step 3
Glass Area
Above Desk Height

Determine the percentage of wall area above desk height which is glass in a typical ten (10) foot wide portion of exterior wall.



First, calculate the total area above desk height:

10 FEET X 6 FEET = 60 SQUARE FEET

Second, calculate how much of that area is glass by adding up the areas of the windows which are above desk height:

3 FEET X 5 FEET = 15 SQUARE FEET
2 FEET X 4 FEET = 8 SQUARE FEET
TOTAL = 23 SQUARE FEET

Then, to determine the percentage of glass area above desk height, divide the second answer by the first:

23/60 = .38 = 38 PERCENT (%)

Table V
Daylight
Availability Factor

Percent Glass Area / Desk Height	75 - 100%	50 - 75%	25 - 50%
NO OVERHANG			
Clear Glass	.62	.59	.56
Tinted Glass	.60	.57	.54
WITH OVERHANG			
Clear Glass	.56	.53	.50
Tinted Glass	.54	.51	.48

Step 3
Daylight
Availability Factor

The amount of daylight available for use depends on several factors. These include window area above desk height, type of glass, whether or not there are exterior overhangs, and the spacing of windows. It should be noted that orientation (direction which window faces, such as north or east) has little effect on the amount of available diffuse daylight.

To obtain the daylight availability factor for your building, you must first know what percentage of your wall area above desk height is glass. As can be seen in Table V, the categories are: 75% to 100%; 50% to 75%; and 25% to 50%. Either, estimate which category describes your situation, or follow the procedure described in the example on the opposite page to determine the category.

Once the percentage of glass area above desk height is known, obtain your daylight availability factor from Table V on the opposite page, using the following steps:

STEP 1: Determine whether you have exterior overhangs projecting at least 2 feet from the outside face of the glass at the top of the window.

STEP 2: Find your glass type (clear or tinted).

STEP 3: Move across in Table V until you reach the appropriate percentage of glass area above desk height.

STEP 4: Enter the value obtained as your answer to the following question.

What is your daylight availability factor?....._____
(Fill-In) (36)

Example: Step 4
Yearly
Energy Savings

What would be the yearly energy savings per fixture in a building which has typical four foot long fluorescent fixtures with four tubes? The building operates for 3,000 hours per year and has a percentage of 65% clear glass above desk height, with no overhangs.

Enter Answer 34 (Watts/Fixture)..... 184

Multiply by Ans. 35 (Hrs. of Oper.).... 3000

Multiply by Ans. 36 (Day.Avail.Factor). .59

Multiply by (Conversion Factor)..... .001

Equals 326
Kilowatt Hours (37)

Example: Step 5
Yearly
Dollar Savings

For our example, if the electrical rate is $.09 (nine cents) per kilowatt hour, yearly dollar savings would be:

Enter Answer 37 (Kilowatt Hours)..... 326

Multiply by (Electric Rate)..... .09

Equals $ 29.30
Dollars (38)

"Sun Spot"
Electrical Rates

Your electrical rate should be calculated from your latest bill by dividing the total dollar amount by the number of kilowatt hours used. By this method you will also be including a proportional amount of any demand charges based upon overall quantities of electricity required.

If you have different rates for summer and winter, you should average together representative bills. When you do the calculation, be sure to remember that you multiply by a number such as .05 (for five cents) or .08 (for eight cents).

Step 4
Yearly
Energy Savings

Using the answers obtained in Steps 1, 2 and 3, you can now determine the annual energy savings per fixture (in kilowatt hours) through operation of a fluorescent fixture dimmed to utilize passive daylight. It should be noted that the conversion factor (.001) converts watt hours to kilowatt hours, allowing us to calculate dollar savings using familiar terms.

Enter Answer 34 (Watts/Fixture)....._____

Multiply by Ans. 35 (Hrs. of Operation).._____

Multiply by Ans. 36 (Day. Avail. Factor)._____

Multiply by (Conversion Factor).....__.001__

Equals _____
Kilowatt Hours (37)

Step 5
Yearly
Dollar Savings

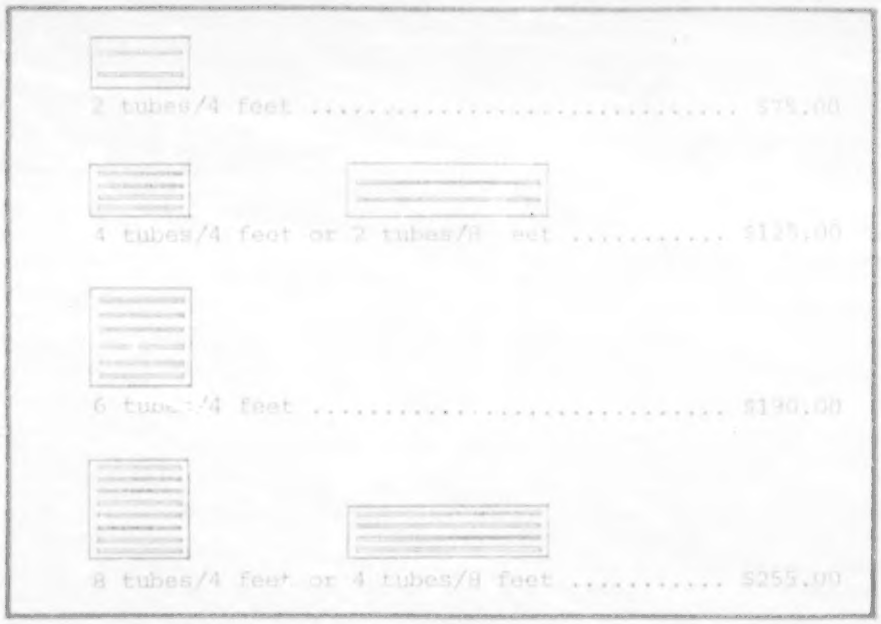
First year dollar savings per fixture can now be calculated by taking the number of kilowatt hours saved and multiplying by your electrical rate per kilowatt hour. See the "Sun Spot" on the opposite page to help determine the electrical rate you should use for the calculation.

Enter Answer 37 (Kilowatt Hours)....._____

Multiply by (Electric Rate)....._____

Equals $_____
Dollars (38)

Table VI
Installed
Cost per Fixture



Example: Step 7
Economic
Analysis

For our example, cost of installation would be $120 (from Table VI). Now the economic factors can be calculated.

Rate of Return:

Enter Answer 38 (Yearly Dollar Savings).. 29.30

Divide by Ans. 39 (Installed Cost)..... 125.00

Multiply by (Percentage Factor)..... 100

Equals 23.4 %
Percent

(40)

Simple Payback:

Enter Answer 39 (Installed Cost)..... 125.00

Divide by Ans. 33 (Yearly Dollar Sav.)... 29.30

Equals 4.3
Years

(41)

Step 6
Installation Cost

With yearly dollar savings now known, we must obtain the per fixture cost of the daylight dimmer control installation before we can begin the economic analysis. To do this, obtain the installed cost for your fixture from Table VI and fill it in as Answer 39.

What is the installed cost for each fixture from Table VI?.....$_____
Dollars (39)

Step 7
Economic Analysis

Calculations can now be made to determine rate of return and simple payback per fixture:

Rate of Return:

Enter Ans. 38 (Yearly Dollar Sav.)....._____

Divide by Ans. 39 (Installed Cost)....._____

Multiply by (Percentage Factor)....._____100_____

Equals _____%
Percent (40)

Simple Payback:

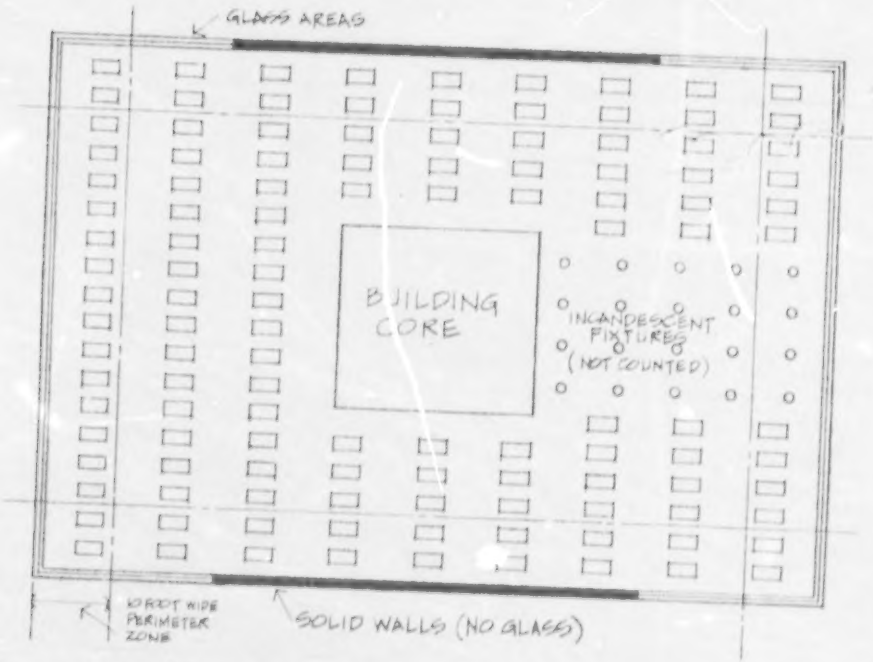
Enter Ans. 39 (Installed Cost)....._____

Divide by Ans. 38 (Yrly. Dollar Sav)..._____

Equals _____
Years (41)

Example: Step 8
Total
Investment Cost

As an illustration of total investment cost, let's see what the cost would be for a three-story building with the typical lighting plan shown below.



As can be counted in the drawing above, there are 38 fluorescent fixtures in front of glass areas within the 10 foot wide primary daylighting zone on each floor. Since the example building has three typical floors, the total number of fixtures which can be modified to take better advantage of available daylight is 114 (38 x 3).

Now we can calculate total investment cost for such a building:

Enter Ans. 39 (Installed Cost)..... $125

Multiply by (No. of Fixtures)..... 114

Equals $ 14,250
Dollars

(42)

Use a similar procedure to count or estimate the number of fluorescent fixtures your building has within the primary daylighting zone (about 10 feet of windows, so that you can determine your total investment cost).

Step **8**
Total
Investment Cost

Now that the economic analysis has been completed for a typical fixture, you may wish to calculate total investment cost. To do this, you should either count or estimate the number of fluorescent fixtures you have within about 10 feet of windows and multiply by the installed cost per fixture. Remember to include in your count only those fixtures that are near windows and are used for almost all daylight hours of building operation.

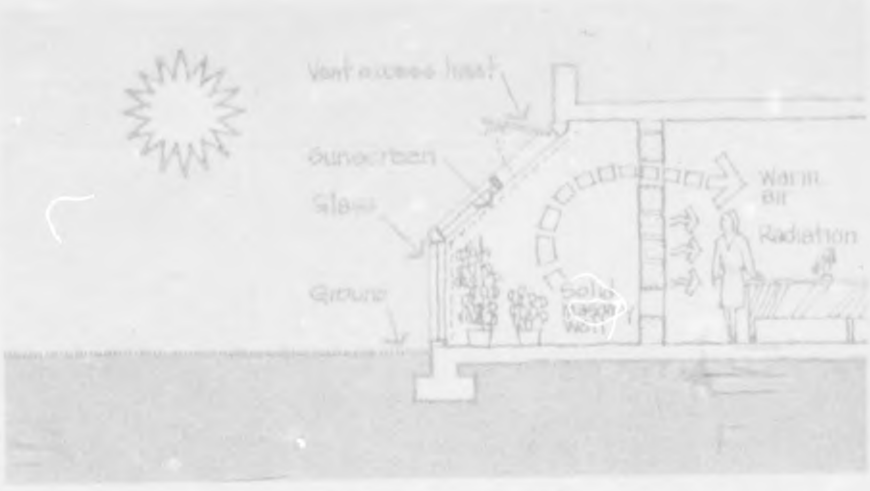
Enter Ans. 39 (Installed Cost)..... _____

Multiply by (No. of Fixtures)..... _____

Equals $ _____
Dollars (42)

If you have evaluated more than one type of fluorescent fixture, you should add up your total investment costs for each type to obtain a total investment cost for all fixtures. In a similar manner you can also determine your total yearly dollar savings.

Isolated Gain



Introduction

Passive solar design techniques can effectively reduce the amount of non-solar energy required by a building to provide for heating and cooling of spaces. This part of the Workbook will help you to determine whether your existing building may be able to benefit from the use of one or more of these passive solar principles. If your responses are favorable, then a technical analysis beyond the scope of this Workbook may identify cost-effective passive options for your building. Also remember that although this Workbook is designed to evaluate existing buildings, it also describes some of the passive solar design principles which should be considered in the planning of future buildings.

Isolated Gain

An isolated gain passive solar system uses a separate sunspace (or greenhouse) to collect the sun's heat, which may then be redistributed to the rest of the building. Sunspaces are attached or integrated into the south side of the building and usually have a wall constructed of heavy materials such as concrete or concrete blocks, to separate it from the rest of the building.

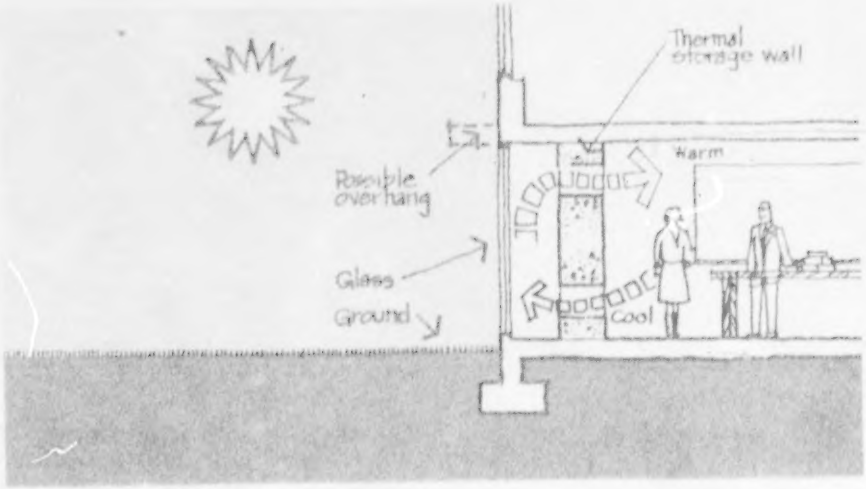
The sunspace system basically functions by absorbing sunlight as heat in the mass of the wall and floor. Some of this heat is released to the air, while some is stored in the wall and floor for later use. The heat collected by the sunspace/greenhouse is transferred to the building either by direct radiation from the walls and/or floors which have been heated, or by vents that circulate the heated air to nearby or distant rooms and spaces.

Many sunspaces have been added onto existing buildings either by building a new structure adjacent to the south wall or by converting an existing south-facing room. In order to consider the sunspace option, an existing building must have available land area to the south, unshaded during the heating season and in a location which would not block existing views or disrupt activities. In addition, the derived benefits of more usable space or room for plant growing would have to be of importance to your building.

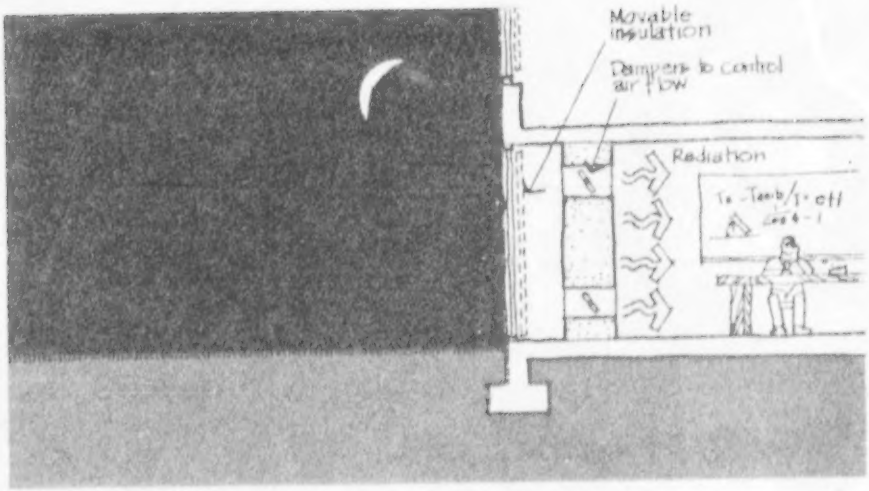
Is the addition of a sunspace a solar option which may be possible and would be functionally beneficial for your building?.....Yes or No

(43)

Indirect Gain/Day



Indirect Gain/Night



Indirect Gain

Indirect gain is an approach to passive solar heating that involves placing a thermal mass between the sun and the area to be heated. Unlike the isolated gain system previously described, the mass (wall) is located several inches inside the single or double glass of the exterior window wall, which prevents re-radiation.

The most common system of indirect gain is the "Trombe wall" named after its French inventor, Felix Trombe. Trombe walls function by absorbing sunlight as heat on a darkly-colored outer surface, and transferring the heat through the wall by conduction. This heat is then released into the space during the night, as needed. During the day the sun's heat can be used directly by adding vents at the top of the wall to allow for immediate air circulation to the space as the hot air rises in front of the wall.

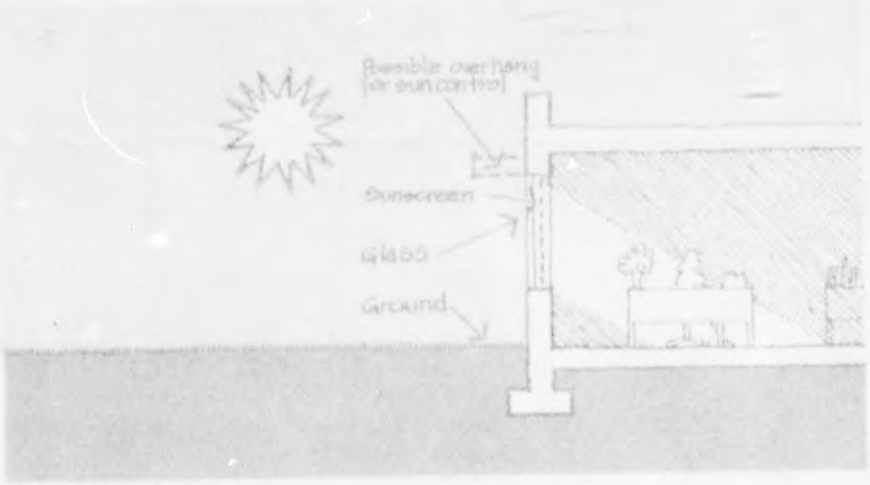
Some existing buildings have been successfully retrofitted with Trombe walls to provide for substantial portions of their heating requirements. For an existing building to be a candidate for an indirect gain Trombe wall passive solar system, it must have either:

- a large area of south-facing exterior masonry walls,
- or, a large area of south-facing glass behind which a thick thermal storage wall could be built without disrupting building functions.

Is the application of an indirect gain passive solar system (Trombe wall) an option which may hold promise for your building?.....Yes or No

(44)

Direct Gain



Direct Gain

Direct gain of solar energy occurs when the sun enters through windows or skylight areas, particularly those which generally face south. When carefully designed, and in some instances when carefully modified, buildings can take advantage of direct gain when it would be beneficial (during the heating season) and limit direct gain when it would be undesirable (during the cooling season).

To take best advantage of direct solar gain, buildings can be designed so that walls, floors and other surfaces absorb and store heat energy for later use, after the sun sets or during cloudy days. While it is generally impractical to add or redesign walls and floors of existing buildings to store heat, it may be possible to reduce excessive heat gains during the cooling season by the use of sun control devices such as shades, louvers, overhangs or window films. To indicate whether your building might be a candidate for sun control devices, please answer:

Does your building have high cooling loads because of direct solar gain through glass areas?.....Yes or No

(45)

Landscaping

Energy needed for heating and cooling of buildings can be greatly reduced by proper site planning and landscaping. While it is true that little can be done to relocate or re-orient an existing building, careful addition of landscaping can be very beneficial. Such elements (trees or shrubs) can reduce heat losses if planted on the windward side of a building, or heat gains if planted to reduce direct solar gains through south-facing glazed areas. Low existing buildings with open surrounding ground area are the best candidates for benefit from this form of solar energy control.

Is your building one which can benefit from new planting of landscaping elements?.....Yes or No

(46)

Discussion of Results

Introduction

Before reading this section, thumb through the pages and review your notes and results. You probably have many questions. Among them may be:

- How reliable are the results?
- How do I protect myself from purchasing inferior equipment?
- How can I get a more detailed evaluation?
- Where can I get more information?

Reliability of Results

It must be stressed that the purpose of this Workbook is only to provide for a quick, but meaningful, preliminary evaluation. Therefore, many of the factors used in the calculations you have performed are based on assumptions and typical situations which may not exactly describe your specific building(s).

To account for differences between typical situations and your actual building(s), the cost-benefit economic results should be interpreted as approximate, with a possible range of error of 25% (or even more in specific cases). To decide whether your building merits further investigation of its solar potential you should consider the most optimistic end of the range. This means that if a payback were calculated to be 10 years, that the payback range might actually be between 7.5 years and 12.5 years, and for the purposes of deciding whether to pursue consideration of solar options, the 7.5 year figure would be reasonable to consider.

Please also remember that you have calculated the simple payback and return on investments using your current energy costs. Since energy costs are rising rapidly, the economics of solar investment may improve.

Assumptions

The solar hot water procedure is based upon several key assumptions, as follows:

- The thermal efficiency of the flat-plate collector is critical to system performance. This Workbook assumes a typical level of collector efficiency.
- The amount of solar radiation received across all areas of New York State has been assumed to be equal. Although it is true that solar quantities vary, actual conditions must be studied on a building-specific basis using measured data, if available.
- The 30% contribution from solar factor was used to give an initial indication of economics based upon a system design in which the collectors will function with high productivity (gallons of hot water per square foot of collector). For many systems, particularly those where total hot water needs are not large, a detailed analysis may show that a solar fraction larger than 30% can be provided economically by solar.
- The "average" values of installation costs are obtained from late 1979 dollar information and are "ball park" figures only.
- The quality of the installation can greatly affect system performance. We have assumed that the system is installed with proper attention to workmanship and detail.
- The evaluation of shading conditions is very simplified and is intended only to indicate if shading may be a problem. The determination of actual shading from surrounding buildings, trees and other items can be very complicated because buildings are not usually oriented north/south and may have different heights, setbacks or irregular shapes. If this Workbook has indicated that serious shading conditions may be present, be sure to have it investigated fully as part of an in-depth technical analysis before you make any solar investments.

Professional Services

A thorough evaluation of solar opportunities will require professional services. As a first step, perhaps the best approach would be to retain an architect/engineer or consultant familiar with solar principles to prepare a brief and inexpensive feasibility study, beginning with the solar options which this Workbook has identified as promising. Only after completion of this feasibility study should complete design services be considered.

Consumer Notes

Consumers interested in solar energy systems should carefully consider the prices and performances of alternate systems. It is wise to compare the materials, equipment and products available before making a final decision on any solar investment. It may also be advisable to determine if local ordinances or solar access laws would protect your solar investment by their ensuring that future construction or development to your south would not shade any solar devices which had already been installed.

Information related to energy conservation and solar energy in New York State, as well as assistance in the use of this Workbook, can be obtained by calling:

- New York State Energy Hot Line (toll-free). . . . . .(800) 342-3722

General information on solar energy, bibliographies suited to specific interests, and lists of solar manufacturers and design professionals, can be obtained (usually free of charge) by calling:

- National Solar Heating and Cooling Information Center (toll-free). . . . . .(800) 523-2929

Summary

Now that you have completed this Workbook, you have increased your knowledge of solar principles and how they may be applied to your existing building. The results obtained should help you to understand the potential of solar energy, and at the same time, assist you in making an informed decision about a possible solar investment.

We hope you have found this Workbook easy to understand, informative and useful. Please mail a copy of your Answer Sheet to us. We appreciate your cooperation and look forward to receiving your results. Remember, even if solar energy does not appear to be a favorable option now, the State Energy Office has available a wide range of information to help you lower your energy expenditures.

Answer Sheets

PLEASE CUT OUT HERE

PLEASE CUT OUT HERE

Answer Sheet

Name of Facility _____

Street Address _____

City/State/Zip Code _____

Governing Agency _____

Name of Key Contact _____

Phone Number Area Code ( ) _____

Date Completed _____

Instructions Please circle or fill-in the answers for your building, as appropriate.

Yes or No (1)

Yes or No (2)

Years (3)

Yes or No (4)

Yes or No (5)

Yes or No (6)

Yes or No (7)

Yes or No (8)

Yes or No (9)

(Fill-in) (10)

Gallons per Year (11)

Gallons from Solar (12)

Collectors (13)

$ Dollars (14)

$ Dollars (15)

% Percent (16)

Years (17)

% Percent (16r)

Years (17r)

Square Feet (18)

Square Feet (19)

Yes or No (20)

Yes or No (21)

Yes or No (22)

Yes or No (23)

Yes or No (24)

Yes or No (25)

Yes or No (26)

Yes or No (27)

Type (28)

Type (29)

(Fill-In) (30)

Yes or No (31)

Yes or No (32)

Yes or No (33)

Watts (34)

Hours (35)

(Fill-In) (36)

Kilowatt Hours (37)

$ Dollars (38)

$ Dollars (39)

% Percent (40)

Years (41)

$ Dollars (42)

Yes or No (43)

Yes or No (44)

Yes or No (45)

Yes or No (46)

Note your thoughts or comments

Please return your Answer Sheet to

New York State Energy Office
Two Rockefeller Plaza
Albany, New York 12223

Attention: Solar Workbook

PLEASE CUT OUT HERE

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Name of Facility _____

Street Address _____

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Yes or No (1)

Yes or No (2)

Years (3)

Yes or No (4)

Yes or No (5)

Yes or No (6)

Yes or No (7)

Yes or No (8)

Yes or No (9)

(Fill-in) (10)

Gallons per Year (11)

Gallons from Solar (12)

Collectors (13)

$ Dollars (14)

$ Dollars (15)

% Percent (16)

Years (17)

% Percent (16r)

Years (17r)

Square Feet (18)

Square Feet (19)

Yes or No (20)

Yes or No (21)

Yes or No (22)

Yes or No _____ (23)

Yes or No _____ (24)

Yes or No _____ (25)

Yes or No _____ (26)

Yes or No _____ (27)

Type _____ (28)

Type _____ (29)

_____ (Fill-In) (30)

Yes or No _____ (31)

Yes or No _____ (32)

Yes or No _____ (33)

_____ Watts (34)

_____ Hours (35)

_____ (Fill-In) (36)

_____ Kilowatt Hours (37)

$ _____ Dollars (38)

$ _____ Dollars (39)

_____ % Percent (40)

_____ Years (41)

$ _____ Dollars (42)

Yes or No _____ (43)

Yes or No _____ (44)

Yes or No _____ (45)

Yes or No _____ (46)

Note your thoughts or comments _____

Please return your Answer Sheet to

New York State Energy Office
Two Rockefeller Plaza
Albany, New York 12223

Attention: Solar Workbook

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Answer Sheet

Name of Facility _____

Street Address _____

City/State/Zip Code _____

Governing Agency _____

Name of Key Contact _____

Phone Number Area Code ( ) _____

Date Completed _____

Instructions Please circle or fill-in the answers for your building, as appropriate.

Yes or No (1)

Yes or No (2)

Years (3)

Yes or No (4)

Yes or No (5)

Yes or No (6)

Yes or No (7)

Yes or No (8)

Yes or No (9)

(Fill-in) (10)

Gallons per Year (11)

Gallons from Solar (12)

Collectors (13)

$ Dollars (14)

$ Dollars (15)

% Percent (16)

Years (17)

% Percent (16r)

Years (17r)

Square Feet (18)

Square Feet (19)

Yes or No (20)

Yes or No (21)

Yes or No (22)

Yes or No _____ (23)

Yes or No _____ (24)

Yes or No _____ (25)

Yes or No _____ (26)

Yes or No _____ (27)

Type _____ (28)

Type _____ (29)

_____ (Fill-In) (30)

Yes or No _____ (31)

Yes or No _____ (32)

Yes or No _____ (33)

_____ Watts (34)

_____ Hours (35)

_____ (Fill-In) (36)

_____ Kilowatt Hours (37)

$ _____ Dollars (38)

$ _____ Dollars (39)

_____ % Percent (40)

_____ Years (41)

$ _____ Dollars (42)

Yes or No _____ (43)

Yes or No _____ (44)

Yes or No _____ (45)

Yes or No _____ (46)

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